Sense Organs on the Antennal Flagellum of a Bird Louse (Mallophaga)

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Abstract: From 25 to 30 sense organs are present on each antennal flagellum of a female bird louse, *Craspedorrhynchus americanus* Emerson. About half of them are clustered at the apex of the third (distal) flagellar subsegment. Tactile hairs, thick-walled chemoreceptors, thin-walled chemoreceptors and coeloconic chemoreceptors can be identified.

The present paper is one of a series, begun about 20 years ago, in which an attempt is being made to examine the flagellar sence organs of one or more species from each order of insects.

The mallophagan antennal flagellum is especially difficult to study because of its very small size. When isolated and unstained it can not be seen with the naked eye. There is almost no literature on the antennal sense organs of the Mallophaga. Occasionally, outline drawings of the antenna are included in systematic papers but at a magnification so low as to give only a superficial impression of the sense organs present. One of the best is that of Essig (fig. 71e, 1942) who includes a drawing of the antenna of *Menodon stramineum* in his description of the order. Some of the sense organs are shown but there are no comments on them either in the text or in the legends for the figures.

MATERIALS AND METHODS

The material examined here consisted of nine adult females of the species *Craspedorrhynchus americanus* Emerson. All had been taken from a red-tailed hawk, *Buteo jamaicensis*, and fixed in Bouins solution.

Since so few specimens were available, the methods used to study them were, necessarily, limited. Most of the individuals were prepared as whole mounts. A few were treated externally with a 0.5% solution of crystal violet in order to identify pores in the cuticle of sense organs (Slifer, 1960). Such openings are characteristic of insect chemoreceptors (Slifer, 1970).

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An antenna from one specimen was stained in acetocarmine and those from another in borax carmine in an attempt to locate sensory neurons and other cells within the antennal lumen. The results were helpful, but not conclusive, in determining the number of neurons present for each sense organ. Another antenna was embedded in paraffin, sectioned and stained with Heidenhain's iron-hemotoxylin. One of the antennae from an individual that had been treated with crystal violet was removed from the slide, soaked in a weak solution of KOH over night and then re-mounted. After this preparation had been studied the antenna was removed again from the slide, embedded in paraffin, cut at 7 μ and the sections stained with Mallory's connective tissue stain.

Another individual was dehydrated, cleared in xylol, dried and examined with the Cambridge scanning electron microscope in the Department of Zoology at the University of Iowa. Debris on the antenna was difficult to remove manually and sonic cleaning was not attempted because of the few specimens on hand.

RESULTS AND DISCUSSION

The mean length of thirteen antennal flagella from *Craspedorrhynchus americanus* females was 111 μ (range 100 to 127 μ). The flagellum is composed of three subsegments of which the first is slightly longer than the other two and the third is the narrowest of the three (fig. 1). The greater part of the wall of a subsegment is heavy but tapers abruptly to a thin membrane between subsegments and is not uniform in depth at a particular level. For example, in a single cross section of the flagellum the wall was 12 μ deep in most regions but decreased to 2 μ at one point.

The conventional terminology for the description of an insect antenna refers to it as if it were extended anteriorly from the front of the head. In *C. americanus* the antennae would be prevented from assuming this position since there is a wide projection of the head wall in front of each antennal base (fig. 5). In the following description this disability will be ignored and the antennae treated as if they could be extended forward.

All of the sense organs on the *first subsegment* are slender and have a tip that tapers to a fine point. They are not affected by a solution of crystal violet applied to the external surface. These are characteristics of tactile hairs. The largest, 24 μ, or less, in length, is located on the ventral side, close to the distal end of the subsegment (fig. 1). From three to five smaller tactile hairs are also present on or near the dorsal surface.

Either two or three tactile hairs were found on the *second subsegment* (fig. 1). As on the first subsegment, the longest was located on the ventral side at the extreme distal border. A second was present on the side opposite the first and a third was sometimes present not far from it.

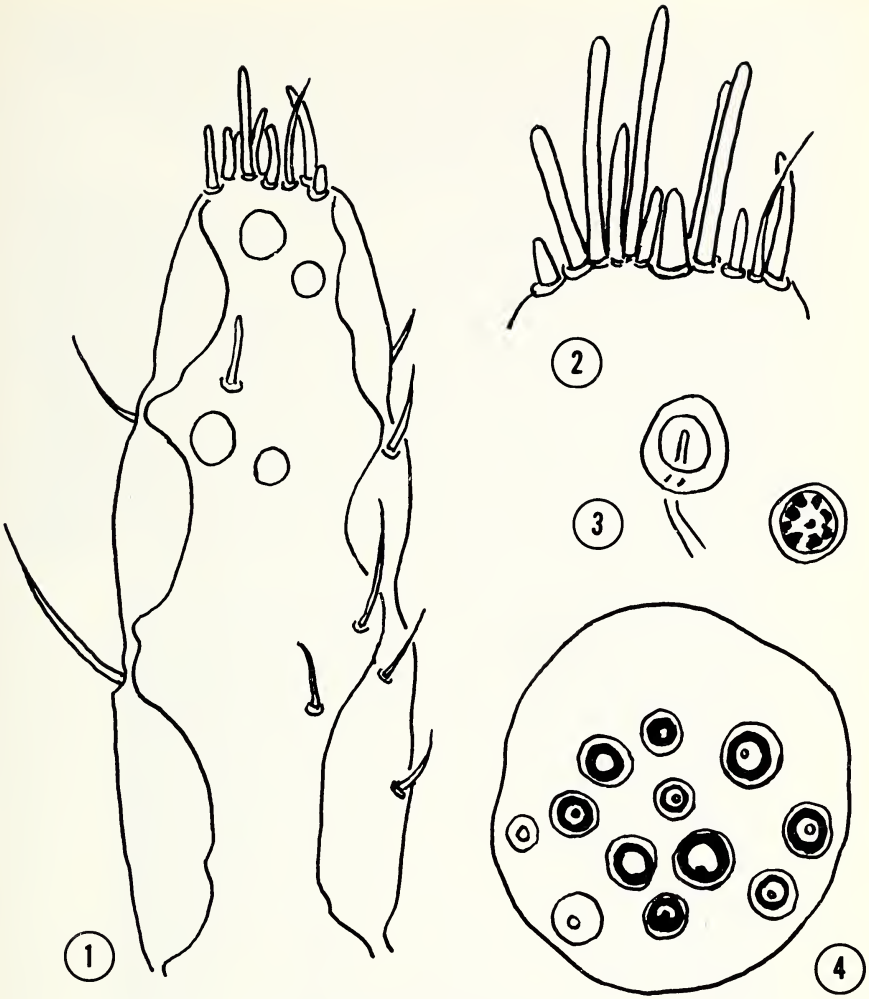

Fig. 1. Lateral view of antennal flagellum of female bird louse. Tuft, composed of thick-walled and thin-walled chemoreceptors and a tactile hair, lies at apex of third subsegment. Circular areas in second and third subsegments are coeloconic chemoreceptors. A single thick-walled chemoreceptor is present near the proximal edge of the third subsegment. All other sense organs are tactile hairs. × 1000.

Fig. 2. Tuft of sense organs from third subsegment. A short, broad thin-walled chemoreceptor lies at the left edge and a larger one close to center of group. A thin tactile hair is second from the edge at right. The others are thick-walled chemoreceptors. × 2000.

Fig. 3. Two coeloconic chemoreceptors from second subsegment as seen in surface view. The peg and the cuticular sheath attached to its base are shown in the sensillum at the left. The cavity of the other contains many small particles that have entered through the opening in the roof. × 2000.

Fig. 4. Cross section through tip of third subsegment to show bases and sockets of twelve sense organs. The socket at the left and that in the lower left corner were added from the next section proximal to this one. × 2000.

In addition to the tactile hairs, two roughly circular, clear areas are visible on the second subsegment on the lateral surface and near the distal end (figs. 1, 3). They are best seen in an antenna that has been isolated and mounted lateral side up. The one farthest anterior is slightly larger than the other. These are coeloconic sense organs. Each contains a minute peg, about 3 μ long, which lies in a cavity from 4 to 9 μ across. The peg stains at the tip with a dye applied externally. This indicates that a pore is present there and that the structure is a chemoreceptor. A cuticular sheath of the type associated with the coeloconic sense organs of species of insects from other orders encloses the dendrites that extend into the peg. Very fine particles, probably originating from the skin and feathers of the host, may enter through the opening in the roof of the chamber and be trapped in the cavity (fig. 3). They stain with crystal violet and may obscure the peg.

Four circular areas are outlined in Essig's drawing of the antenna of *Menopon stramineum* (fig. 71e, 1942). It is possible that these are coeloconic sense organs of the type described here. However, of the four, two are located, in Essig's figure, on the pedicel and one each on subsegments one and two. This arrangement is very different from that described here.

It is interesting that Miller (1970a, 1970b, 1971) has reported that a single coeloconic sensillum is present on the terminal subsegment and on the one just proximal to it in several species of Anoplura. His studies were all made with the scanning electron microscope. Except for their very different mouth parts, the Mallophaga and the Anoplura share many characteristics and have been placed in the same order by some systematists (Ross, 1956). The occurrence of conspicuous coeloconic chemoreceptors on the last two subsegments of species from both of these orders adds one more feature to those that they have in common.

The *third subsegment* has on it a larger number and greater variety of sense organs than do those proximal to it. Most of them are concentrated in a tuft at the apex. As in the second subsegment, two coeloconic chemoreceptors are present on the lateral surface and close to the distal end. Two small tactile hairs, from 3 to 10 μ long may be seen on the dorsal surface but were not always found. A single stout hair, from 9 to 16 μ long occurs on the ventro-lateral surface. This is usually, but not always, close to the proximal border of the subsegment.

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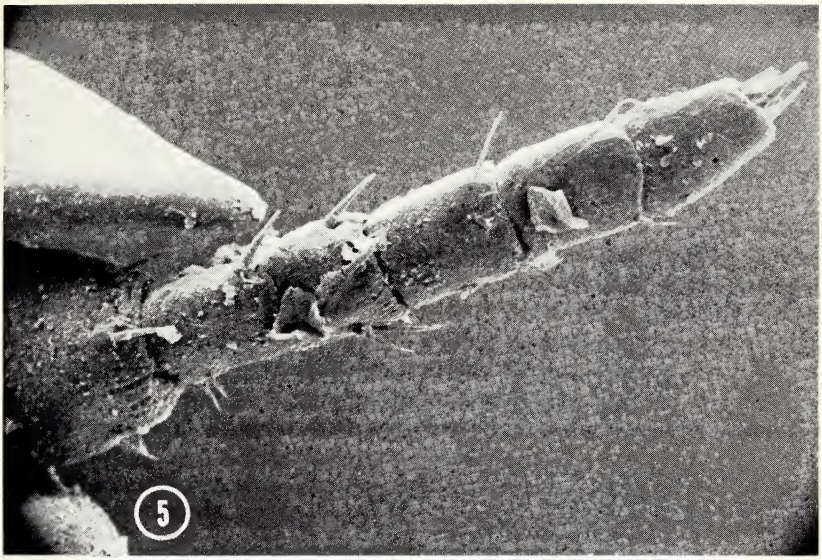
FIG. 5. Scanning electron micrograph of left antenna showing ventral surface of scape, pedicel and three flagellar subsegments. A projection of the side of the head extends to the middle of the pedicel and would prevent forward extension of the antenna. A small pore may be seen on the third subsegment. × 540.

FIG. 6. Scanning electron micrograph of apex of third subsegment showing tuft of sense organs. The smaller of the two thin-walled chemoreceptors is in the front row and the slender tactile hair is near the left edge. The remaining sense organs are thick-walled chemoreceptors. Several sense organs are hidden by those shown. × 5500.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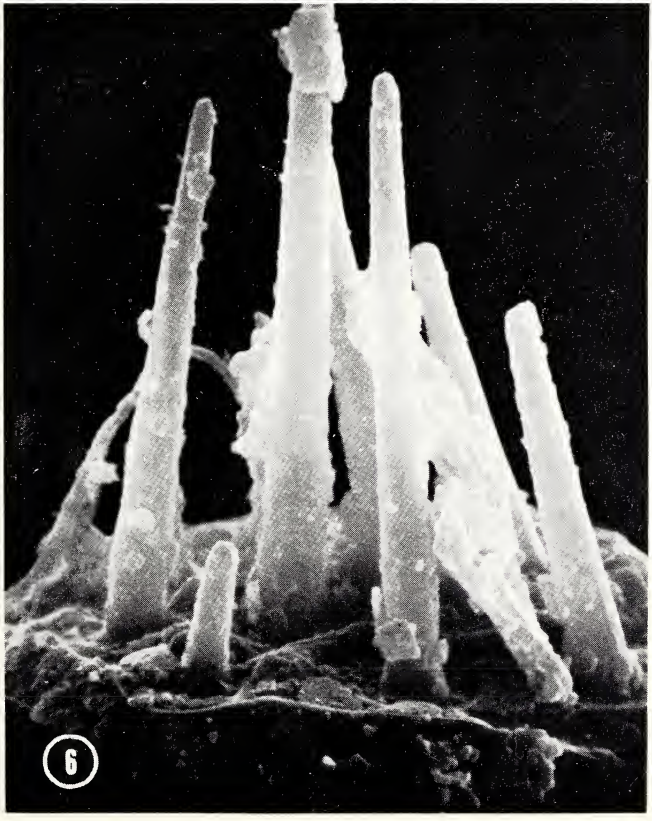
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It stains at the tip with crystal violet and so must be classed as a thick-walled chemoreceptor.

A pore, about one micron in diameter, may be seen in fig. 5. A pair of similar structures on the terminal subsegment of several species of Anoplura examined by Miller (1969, 1971) have been referred to as pore organs. The anopluran pore is surrounded by a ring of fine grooves that radiate from it. Grooves were absent in *C. americanus* and the pore looks very much like the opening at the cuticular surface of the duct of an epidermal gland. Such pores are commonly present on insect antennae, as well as elsewhere on the body. If the pore in Miller's material is a gland opening, the slits surrounding the pore may aid in the spreading of a secretion. Figure 7 in Miller's paper (1969) suggests that this may occur. Whether or not this is the proper interpretation could best be determined with sections examined with the transmission electron microscope.

The conspicuous cluster of hairs at the distal end of the third subsegment is composed of two thin-walled chemoreceptors, from 7 to 9 thick-walled chemoreceptors and one tactile hair. All are set close together in well-developed sockets in a thin membrane (figs. 2, 4, 6). The blunt-tipped thick-walled chemoreceptors range in length from 6 to 22 μ. They stain at the tip with crystal violet. This indicates that a pore is located here at which the distal ends of sensory dendrites are exposed. The thin-walled chemoreceptors, in contrast, stain over their entire surface. Many small pores penetrate the walls of such structures in other species of insects and the lumen is filled with the branches of sensory dendrites (Slifer, 1970).

The thin-walled pegs vary in length from 3 to 9 μ. The larger one is located on the dorsal surface and the other is in the dorso-lateral region. The slender tactile hair ranges in length from 7 to 15 μ. It is unaffected by stain applied externally.

A small number of sensory neurons, accompanied by their sheath cells, lie in the lumen of the third subsegment. These were best seen in the acetocarmine and borax carmine whole mounts and in the sections stained with Heidenhain's iron-hemotoxylin. Since approximately 16 sense organs are present on this subsegment, the number of neurons innervating each receptor must be small. It was not possible to determine the number exactly.

In summary, the antennal flagellum of a female *Craspedorrhynchus americanus* is well provided with tactile hairs and chemoreceptors. All of them are of types that have been described previously for species of insects from other orders.

Literature Cited

ESSIG, E. O. 1942. College Entomology, p. 197. The Macmillan Company, New York.

MILLER, F. H., JR. 1969. Antennal tuft organs of *Pediculus humanus* Linn. and *Phthirus pubis* (Linn.). (Anoplura: Pediculidae). Jour. N.Y. Ent. Soc., **77**: 85–89.

———. 1970a. Scanning electron microscopy of antennal structures of *Polyplax serrata* (Burmeister) (Anoplura: Hoplopleuridae). Jour. N.Y. Ent. Soc., **78**: 33–37.

———. 1970b. Scanning electron microscopy of *Solenopotes capillatus* Enderlein Anoplura: Linognathidae). Jour. N.Y. Ent. Soc., **78:** 139–145.
———. 1971. Scanning electron microscopy of antennal structures of five *Haematoponus* (Anoplura: Haematoponidae). Jour. N.Y. Ent. Soc., **79:** 19–26.
Ross, H. H. 1956. A textbook of Entomology, 2nd ed., p. 254. John Wiley and Sons, Inc. New York.
Slifer, E. H. 1960. A rapid and sensitive method for identifying permeable areas in the body wall of insects. Ent. News, **71:** 179–182.
———. 1970. The structure of arthropod chemoreceptors. Ann. Rev. Ent., **15:** 121–142.

BOOK REVIEW

Insect Diseases. George E. Cantwell, ed. 2 volumes. 595 pp. + 21 pp. glossary. Marcel Dekker, New York. $54.00. 1974.

Interest in insect diseases has increased in recent years. The primary reason for it is the attention given insect pathogens as potential biological control agents. The resistance of insect vectors of disease agents and of agricultural pests to chemical insecticides, coupled with the public awareness of the environmental pollution and the concern about the continuous use of chemical insecticides made the large scale uses of "living insecticides" a reality. There is now a definite need for modern, comprehensive descriptions of insect pathogens and diseases, for students in colleges and universities as well as for researchers. The scholarly treatment of this subject by the late Prof. Steinhaus is partly outdated and the remaining copies of the classic 2 volumes are quite expensive. Cantwell's volumes are concise but also expensive, even though the books have been produced from non-justified typescripts by camera copy. The first volume contains 5 chapters: Diagnostic Techniques by G. M. Thomas; Virus and Rickettsial Diseases by J. L. Vaughn; Bacterial Diseases by R. M. Faust; Mycoses by J. N. Bell, and Protozoan Infections by W. M. Brooks. The six chapters of the second volume comprise: Symbiology-Mutualism between Arthropods and Microorganisms, by G. M. Boush and H. C. Coppel; Nematode Infections by N. R. Nickle; Radiation, Neoplasms, Carcinogenic Chemicals, and Insects by J. C. Harshberger; Hormonal-induced Pathologies by W. F. Walker; Genetic Pathology by P. J. Bryant; and Honey Bee Diseases, Parasites, and Pests by G. E. Cantwell. The fact that one has to look for the index to the first volume at the end of the second indicates that these volumes were prepared as a single book, then split arbitrarily, disregarding the need for separate indices. Apart from this inconvenience, the volumes provide a useful introductory text covering the entire field of insect pathology for undergraduate and graduate entomology students. The inclusion of nearly 2 dozen laboratory exercises provides a handy guide to tests that were chosen so as to require only simple equipment. Each chapter is followed by an extensive bibliography. The overview of various areas of insect pathology is good and the text can be recommended for an introductory level course.

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